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(54) TREATMENT OF WATER OR AQUEOUS WASTE MATERIAL

(71) We, BOC INTERNATIONAL LIMITED (formerly The British Oxygen Company Limited), an English company of Hammersmith House, London W6 9DX, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the treatment of water or aqueous waste material having an oxygen demand. It is particularly suited to the treatment of such materials as sewage, sewage sludge and organic industrial wastes.

Conventional methods of treating such materials usually involve prolonged aeration of the material. This encourages micro-organisms present in the incoming material or introduced with activated sludge to break down the offensive portions of the waste into a form more fit for disposal whilst avoiding as far as possible the production of offensive products such as sulphur compounds. The primary need in such systems is that of reliability and sewage disposal authorities are therefore constrained to keep to methods that do not rely on external supplies. The conventional methods meet this requirement by using air as the treating agent and including stand-by power supplies to guard against failure of the mains service. Conventional systems do however have the disadvantages of being slow and providing low rates of treatment and as a result occupy considerably areas of land.

Many proposals have been made for improving the capacity of waste treatment plant by substituting oxygen for air in the treatment and various methods have been held out to be the first commercially applicable forms of sewage treatment using oxygen. None of these has however overcome the fundamental objection to an oxygen system that it introduces the need to rely on an external source of oxygen and thus is subject to such problems as the effect on delivery services of winter weather and industrial disputes.

According to the invention there is provided a process in which aqueous liquor having an oxygen demand is contacted with a treatment gas having an oxygen content in the range 70 to 95% by volume and at least a part of the effluent gas so produced is subjected to an enrichment step to restore its oxygen content to the treatment level and is then recycled. Preferably the whole of the effluent gas is subjected to the enrichment step.

Oxygen consumed in the treatment process is replaced by introducing, as a source of oxygen, an oxygen-containing gas, preferably air, into the system.

The aqueous liquor may be water, for example effluent water from an original source such as a reservoir, or it may be sewage or industrial effluent having a high oxygen demand. In using the process of the invention for sewage treatment, the liquor is preferably a mixture of untreated biological waste material and activated sludge recycled from a previous treatment. The proportion of recycled sludge in the mixture is preferably in the range 60 to 95% by weight.

The proportion of oxygen in the treatment gas is preferably in the range 80 to 90% by volume. The most suitable treatment gas is oxygen-enriched air. This can be produced by a variety of methods including for example, low temperature processing, diffusion or adsorption. An advantageous feature of the present invention is that a single unit in the treatment cycle can be used for enrichment to the desired level of both incoming oxygen-source gas and the effluent gas.

With such an arrangement the oxygen source gas can be added to any point in the cycle but preferably it is introduced into the enrichment unit or just upstream thereof.

If desired, the treatment gas can be enriched with ozone.

Thus the invention also provides a process for the treatment of aqueous liquor having an oxygen demand, in which a gas stream containing 70 to 95% by volume oxygen is ozonised, the ozonised gas is used to contact the liquor to be treated, and at least a part of the effluent gas so produced is subjected to an enrichment step to restore its oxygen content and is recycled to the ozonisation stage.

Ozone treatment of water is mainly useful in the final cleansing, sometimes known as polishing, of contaminated water. This may be effluent water from an original source, such as a reservoir, or sewage or industrial effluent which has previously been subjected to a primary, sedimentation, step and secondary, aeration, step. Ozone treatment can also be applied to heavily contaminated water, such as sewage.

Alternatively in a sewage treatment process having a primary sedimentation a two-stage oxygenation procedure can be adopted, using a treatment gas with an oxygen content of 70 to 95% by volume as a secondary treatment and an ozonised stream of such oxygen-containing gas as a tertiary i.e. polishing, treatment. Such a combination allows a unified plant for both the oxygenation stages, using a single enrichment means.

The proportion of oxygen in the gas to be ozonised is preferably in the range 80 to 90% by volume, the most suitable source of this gas being oxygen-enriched air.

The oxygen-source gas can be added at any point in the ozonisation cycle but preferably it is introduced into the enrichment unit or just upstream thereof.

Contact between the aqueous liquor and the treatment gas can be effected either in a single tank or series of tanks. The oxygen-containing gas is preferably introduced into the liquor through a diffuser, for example a perforated pipe or a porous plug. In addition to the agitation of the waste material caused by the introduction of the treatment gas it is usually also important to provide mechanical agitation in order to promote good contact between the oxygen and the waste material. Such contact can alternatively or additionally be promoted by introducing the oxygen source gas directly into the aqueous liquor. Part of the oxygen introduced is adsorbed by the liquor and the remainder is recovered in the effluent gas. The need to recover the effluent gas makes it necessary to employ a closed tank. This allows the alternative of effecting the oxygen contact by passing the oxygen over the surface of the waste material whilst subjecting it to mechanical agitation. In the secondary treatment of sewage with oxygen-enriched air, the effluent gas also contains nitrogen, carbon dioxide, water vapour and minor amounts of other gases, for example sulphur compounds. A preliminary purification step can be included in the enrichment stage so as to reduce the carbon dioxide content of the effluent gas. Such a preliminary step is particularly desirable when handling strong sewage or other waste of high organic content.

The preferred means for enriching the oxygen content of the effluent gas is a pressure swing adsorption unit in which beds of adsorbent material operate on a pressure variation cycle at relatively constant temperature to remove unwanted components from the gas. There are a number of variants of the basic system which may be employed. In one typical pressure swing system an adsorbent bed goes through the sequence of operations: admit feed; reduce pressure to release initial product; purge with a suitable gas stream, displacing adsorbed impurities with simultaneous release of further product; and optionally evacuate to carry further towards completion the removal of adsorbed impurities. While both the treatment process and the operation of the pressure swing unit can be effected with an intermittent or pulsed supply of enriched oxygen a continuous smooth supply may readily be provided by the provision of multiple parallel beds in the pressure swing unit. The operation of these parallel beds is then arranged on an appropriately stepped time cycle. For example with four beds and four steps in a time sequence at a given time each bed will be operating in a different step of the cycle.

The present invention is characterised by the introduction of an oxygen source gas, typically air, into an aqueous liquor, typically in such a way that the air is a net contributor of oxygen equivalent to the oxygen consumed by the treatment process. While the oxygen source gas may be introduced at several alternative points in a pressure swing sequence, a convenient point of introduction is as the purge gas. Thus in such a case the introduction of air to a particular bed follows immediately after the initial drawing off of oxygen, a further portion of product normally being released during the admission of the purge stream. Introduction of the oxygen source gas may be at any convenient pressure a from atmospheric pressure upwards.

Contact with the treatment gas can either be effected in a single tank or in a series of tanks.

The system offers the advantage of being self contained, requiring nothing more than a power source and thus rivals conventional aeration systems in reliability. At the same

time, by virtue of the high level of oxygen in the treatment gas, it permits a higher throughput of sewage than previous proposals for oxygen sewage treatment.

Figure 1 is a diagrammatic flow sheet of a single stage sewage treatment according to the invention;

Figure 2 is a diagrammatic flow sheet of a three-stage sewage treatment according to the invention;

Figure 3 is a diagrammatic flow sheet of a pressure swing adsorption unit for use in oxygen enrichment in the process of the invention.

In the system shown in Figure 1 sewage is fed into a tank 11 through a supply pipe 12 and recycled sludge through pipe 13. These are contacted with oxygen-enriched air introduced through a supply pipe 14 and a gas diffuser 15. The contents of the tank 1 are agitated by stirrers 19. Effluent gas collecting in the head-space above the liquid in the tank 11 has a high oxygen content but also contains, nitrogen, carbon dioxide, water vapour and sulphurous gases. It is withdrawn through a pipe 20 and introduced into a pressure swing adsorption unit 17. The unit 17 removes impurities from the effluent gas and restores it to an acceptably high oxygen content for recycle through pipe 14 to the tank 11. A supply of air to make up for the oxygen adsorbed by the sewage is introduced into the pressure swing unit 17 through a line 21. Treated sewage is withdrawn from the tank 11 through a line 16 and passed to a clarifier 22 from which at least a part of the sludge is recycled through the line 13 and any portion for disposal is withdrawn through a line 24. Circulation of gas and recycle of the sewage sludge is effected by pumps (not shown in the diagram). A by-pass line 25 permits a portion of the effluent gas to be directly recycled to the tank 11 and thus reduce the load on the pressure swing unit.

In the system shown in Figure 2, a series of tanks 31, 41 and 51, each similar to tank 11, is provided. Parts of the system similar to those of Figure 1 are given the same reference numerals. Tank 31 receives sewage through a line 32 and recycled sludge through a line 33. These are contacted with oxygen-enriched air introduced through a line 34 and gas diffuser 15. Treated sewage is withdrawn through a line 36 and introduced into the tank 41 to be contacted with effluent gas leaving the tank 31 through a pipe 42. Similarly, treated sewage from the tank 41 is passed through a line 46 to the tank 51 for contact with the effluent gas from tank 41 introduced through line 52 but the effluent gas from the tank 51 is passed to the pressure swing unit 17 through a pipe 60. Treated sewage from the tank 51 is passed through a line 56 to a clarifier 62 from which at least a part of the sludge is recycled through the line 33.

Figure 3 shows a set of four adsorption beds 71, 81, 91 and 101 each containing adsorbent material 72. Each bed is provided with a valved supply pipe (73, 83, 93 and 103 respectively) for the impure oxygen, a valved outlet line (74, 84, 94 and 104) for the purified oxygen and valved outlet lines (75, 85, 95 and 105) for the discharged impurities. Impure oxygen is first introduced into the bed 71 and purified oxygen is withdrawn through the line 74. A front of adsorbed material passes towards the outlet end of the bed. Before it reaches the outlet end the valve in line 73 is closed and the valves in line 83 and 84 are opened thus switching the feed gas from the bed 71 to bed 81. The valve in line 74 is then closed and the valve in line 75 opened. A vacuum pump is then attached to line 75 to withdraw impurities from the bed 71. When the bed 81 is almost exhausted the valves associated with it are switched in a manner similar to that described for bed 71 and the gas flow is switched to the bed 91. In turn gas flow is switched from bed 91 to bed 101. When bed 101 has reached the stage of being almost exhausted, the bed 71 is switched back from desorption to adsorption and the feed gas switched back to bed 71.

In a typical treatment cycle a treatment gas containing 90% oxygen would be passed into the sewage at a pressure of 8 psig. This pressure is sufficient to maintain a supply to the pressure swing unit. Alternatively the supply pressure to the sewage can be at an elevated level (for example 25 psig) such that desorption of the pressure swing beds can be effected without use of a vacuum pump. The temperature of the treatment in both such cases would normally be ambient.

WHAT WE CLAIM IS:—

1. A process for treating an aqueous liquor having an oxygen demand in which the liquor is contacted with a treatment gas having an oxygen content in the range 70 to 95% by volume, at least a part of the effluent gas so produced is subjected to an enrichment step to restore its oxygen content to the treatment level and is then recycled.

2. A process for treating an aqueous liquor having an oxygen demand in which a gas stream containing 70 to 95% by volume oxygen is ozonised, the liquor is contacted with the ozonised gas, and at least a part of the effluent gas so produced is subjected to an enrichment step to restore its oxygen content and is recycled to the ozonisation stage.

3. A process as claimed in claim 1 or claim 2, wherein the aqueous liquor is a mixture of untreated sewage material and activated

sludge recycled from a previous treatment.

4. A process as claimed in claim 3, wherein the proportion of recycled sludge in the mixture is in the range 60 to 95% by weight.

5. A process as claimed in any preceding claim, wherein the oxygen content of the effluent gas is restored to a level in the range 80 to 90% by volume.

6. A process as claimed in any preceding claim, wherein the treatment gas is oxygen-enriched air.

7. A process as claimed in any preceding claim, wherein a single unit is used for enrichment to the desired level of both incoming oxygen-source gas and the effluent gas.

8. A process as claimed in any preceding claim, wherein the source of oxygen is introduced into the enrichment unit or just upstream thereof.

9. A process as claimed in any preceding claim, wherein contact between the aqueous liquor and the treatment gas is effected either in a single tank or in a series of tanks.

10. A process as claimed in any preceding claim, wherein the treatment gas is introduced into the aqueous liquor through a diffuser.

11. A process as claimed in any preceding claim, wherein the aqueous liquor is first treated with a gas of enriched oxygen content but no ozone and then treated with an ozonised stream of such oxygen-containing gas.

12. A process as claimed in any preceding claim, wherein mechanical agitation of the aqueous liquor is provided in order to promote good contact between the treatment gas and the aqueous liquor.

13. A process as claimed in any preceding claim, wherein oxygen-source gas is introduced directly into the aqueous liquor.

14. A process as claimed in any preceding claim, wherein the enrichment stage includes a preliminary purification step to reduce any carbon dioxide content of the effluent gas.

15. A process as claimed in any preceding claim, wherein the oxygen content of the effluent gas is increased by a pressure swing adsorption unit in which beds of adsorbent material operate on a pressure variation cycle at relatively constant temperature to remove unwanted components from the gas.

16. A process as claimed in claim 1, substantially as described herein with reference to the accompanying drawings.

17. Aqueous liquor whenever treated by a process as claimed in any preceding claim.

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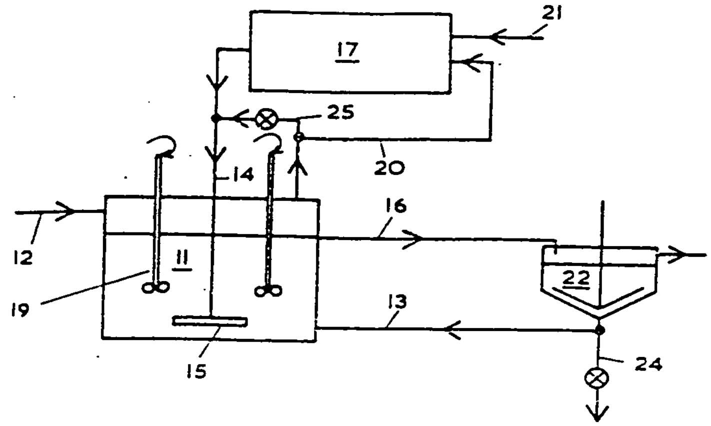
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FIG. 1

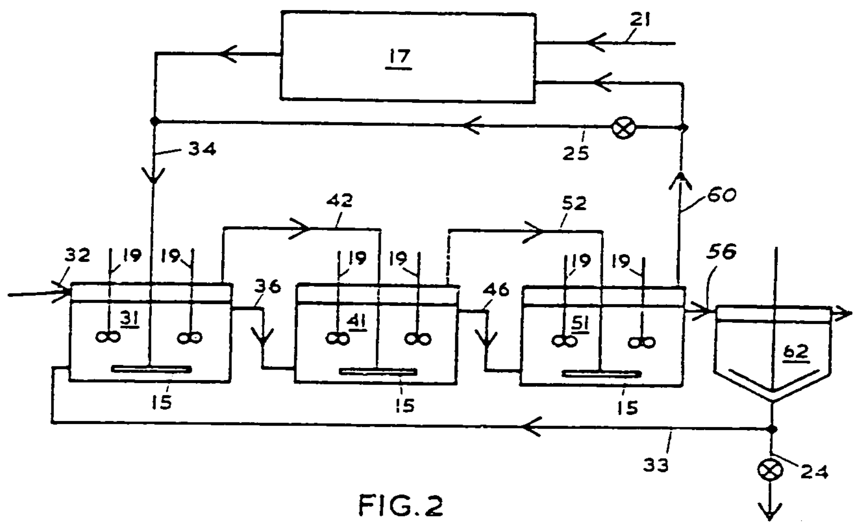
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FIG. 2

1417573 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

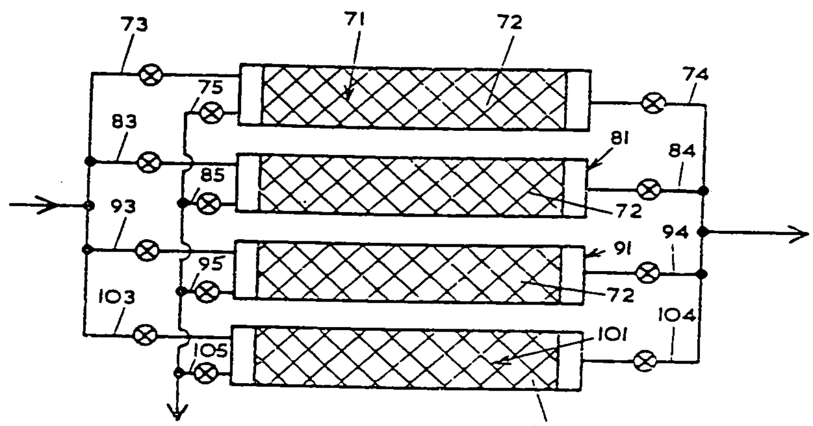

FIG. 3